What is claimed is:

1. A device comprising:

a first magnetic region having a first magnetization;

a control region forming a first interface with the first magnetic region;

a second magnetic region forming a second interface with the control region, the second magnetic region having a second magnetization that is substantially colinear with the first magnetization; and

a wire positioned relative to the control region so that a current through the wire creates in the control region a magnetic field that rotates spins of the electrons injected through the control region between the first magnetic region and the second magnetic region.

2. The device of claim 1, wherein the first magnetization and the second magnetization are substantially parallel to each other.

3. The device of claim 1, wherein the first magnetization and the second magnetization are substantially anti-parallel to each other.

4. The device of claim 1, further comprising:

a first terminal connected to the first magnetic region;

a second terminal connected to the second magnetic region; and

a third terminal and a fourth terminal connected to ends of the wire, wherein a signal applied to the third and fourth terminals controls a current between the first and second terminals.

5. The device of claim 4, wherein the current between the first and second terminals includes a component that is proportional to the square of a current that the signal causes in the wire.

6. The device of claim 4, wherein the signal oscillates with a first frequency, and the current between the first and second terminals includes a component that oscillates with a second frequency that is twice the first frequency.

7. The device of claim 4, wherein the signal includes a first component that oscillates with a first frequency and a second component that oscillates with a second frequency, and the current between the first and second terminals includes a component that oscillates with a third frequency that is equal to a difference between the first frequency and the second frequency.

8. The device of claim 4, wherein the signal includes a first component that oscillates with a first frequency and a second component that oscillates with a second frequency, and the current between the first and second terminals includes a component that oscillates with a third frequency that is equal to a sum of the first frequency and the second frequency.

9. The device of claim 1, wherein the control region is such that an electron spin relaxation time of the control region is longer than a transit time of the electrons traversing the control region.

10. The device of claim 1, wherein the control region comprises a semiconductor material.

11. The device of claim 10, wherein the semiconductor material is selected from a group consisting of Si, Ge, GaAs, GaInAs, Ge, ZnSe, ZnCdSe, and alloys and combinations of these materials.

12. The device of claim 10, wherein the semiconductor material contains an n-type doping.

13. The device of claim 1, wherein the first magnetic region comprises a ferromagnetic material.

14. The device of claim 1, wherein the wire has a cross-sectional dimension less than 100 nm.

15. The device of claim 1, wherein the control region has a thickness less than 100 nm.

16. The device of claim 1, further comprising a substrate wherein:

the wire comprises a conductive region on the substrate;

the first magnetic region overlies the conductive region;

the control region overlies the first magnetic region; and

the second magnetic region overlies the control region.

17. The device of claim 16, further comprising an insulating layer between the conductive region and the first magnetic region.

18. The device of claim 16, wherein the insulating layer has a thickness that is greater than 1 nm and less than 20 nm.

19. The device of claim 1, further comprising:

a first anti-ferromagnetic layer adjacent to the first magnetic region, wherein the first anti-ferromagnetic layer fixes a direction of the first magnetization; and

a second anti-ferromagnetic layer adjacent the second magnetic region, wherein the second anti-ferromagnetic layer fixes a direction of the second magnetization.

20. The device of claim 1, further comprising:

a first δ-doped layer between the first magnetic region and the control region; and

a second δ-doped layer between the second magnetic region and the semiconductor region, wherein the first and second δ-doped layers increase tunneling transparency of the ferromagnetic-semiconductor junctions.

21. The device of claim 1, further comprising a substrate wherein:

the first magnetic region is on the substrate;

the control region overlies the first magnetic region; and

the second magnetic region overlies the control region.

22. The device of claim 21, wherein the substrate comprises an anti-ferromagnetic material that is under the first magnetic region and that fixes the direction of the first magnetization.

23. The device of claim 21, wherein the wire comprises a first segment laterally spaced from a first side of the control region.

24. The device of claim 23, wherein the wire further comprises a second segment laterally spaced from a second side of the control region.

25. The device of claim 24, wherein the first segment and the second segment are connected in series such that current in the first segment has a direction opposite to current in the second segment.

26. The device of claim 21, wherein:

the control region comprises a plurality of parts, wherein each part is laterally separated from an adjacent part, and

the wire comprises a plurality of segments that reside in separations between the parts of the control region.

27. The device of claim 26, wherein the segments are connected such that current in each of the segments has a direction opposite to current in an adjacent one of the segments.

28. The device of claim 1, further comprising a substrate, wherein the first magnetic region, the second magnetic region, and the control region are a surface of the substrate, with the control region being between the first magnetic region and the second magnetic region.

29. The device of claim 28, wherein the wire comprises a first section overlying the control region.

30. The device of claim 28, wherein the substrate comprises a conductive section that underlies the control region and forms at least a part of the wire.

31. The device of claim 30, wherein the wire further comprises a second section that overlies the control region and that is connected in series with the conductive section in the substrate.

32. A method for generating an output signal having a frequency differing from that of an input signal, comprising:

applying a first voltage difference between a first magnetic region and a second magnetic region that respectively form a first interface and a second interface with a semiconductor region that is between the first and second magnetic regions;

driving the input signal current through a wire that is adjacent to the semiconductor region to create a magnetic field that rotates spins of electrons injected through the semiconductor region between the first magnetic region and the second magnetic region; and

extracting the output signal from a current resulting from injection of spin-polarized electrons between the first magnetic region and the second magnetic region.

33. The method of claim 32, wherein the frequency of the output signal is twice that of the input signal.

34. The method of claim 32, wherein the input signal includes a first component having a first frequency and a second component having a second frequency, and the frequency of the output signal is equal to a difference between the first frequency and the second frequency.

35. The method of claim 32, wherein the input signal includes a first component having a first frequency and a second component having a second frequency, and the frequency of the output signal is equal to a sum of the first frequency and the second frequency.

36. The method of claim 32, wherein the first magnetic region has a first magnetization, the second magnetic region has a second magnetization, and the first magnetization is substantially colinear with the second magnetization.

37. The method of claim 32, wherein the semiconductor region is such that an electron spin relaxation time of the semiconductor region is longer than a transit time of the electrons traversing the semiconductor region.